tage of the photographic method; there is no chance of error or forgetfulness. The observations sent home to the Royal Society will enable those on whom the labour and responsibility of reducing them will fall to almost reconstruct the eclipse for themselves.

"We may remark in conclusion that not only may we hope for many important results in solar physics if the weather be favourable, but that the benefit to science arising out of the expedition will be by no means limited to the eclipse results. Already Drs. Vogel and Schuster, the latter of whom is a distinguished pupil of Owens College, have done some important work on the varying intensities of the different parts of the solar spectrum at different times of the day, and in different climates on the voyage out, but both will remain some months in India to pursue their inquiries—Dr. Vogel in photographing the solar spectrum, with variously coloured photographic films; Dr. Schuster in establishing himself at a considerable height for the purpose of photographing the various solar phenomena and the spectra of some of the most important of the southern stars. The observers, all of whom have made considerable sacrifices in travelling a quarter round the globe and back again in the pursuit of science, certainly command our sympathy and deserve success. The Government grant of 1,000*l*. has been the means of calling forth, and, we hope sincerely, rendering fruitful, a vast amount of individual effort which would have been powerless without it. We may add that all the instruments have either been purchased by the Royal Society out of its own funds or lent by private individuals."

*ON THE DISSIPATION OF ENERGY**

THE second law of thermodynamics, and the theory of dissipation founded upon it, has been for some years a favourite subject with mathematical physicists, but has not hitherto received full recognition from engineers and chemists, nor from the scientific public. And yet the question under what circumstances it is possible to obtain work from heat is of the first importance. Merely to know that when work is done by means of heat, a so-called equivalent of heat disappears, is a very small part of what it concerns us to recognise.

A heat-engine is an apparatus capable of doing work by means of heat supplied to it at a high temperature and abstracted at a lower, and thermodynamics shows that the fraction of the heat supplied capable of conversion into work depends on the limits of temperature between which the machine operates. A non-condensing steam-engine is not, properly speaking, a heat-engine at all, inasmuch as it requires to be supplied with water as well as heat, but it may be treated correctly as a heat-engine giving up heat at 212° Fahr. This is the lower point of temperature. The higher is that at which the water boils in the boiler, perhaps 360° Fahr. The range of temperature available in a non-condensing steam-engine is therefore small at best, and the importance of working at a high pressure is very apparent. In a condensing engine the heat may be delivered up at 80°Fahr.

It is a radical defect in the steam-engine that the range of temperature between the furnace and the boiler is not utilised, and it is impossible to raise the temperature in the boiler to any great extent, in consequence of the tremendous pressure that would then be developed. There seems no escape from this difficulty but in the use of some other fluid, such as a hydrocarbon oil, of much higher boiling point. The engine would then consist of two parts—an oil-engine taking in heat at a high temperature, and doing work by means of the fall of heat down to the point at which a steam-engine becomes available; and secondly, a steam-engine receiving the heat given out by the oil-engine and working down to the ordinary atmospheric temperature.

Heat-engines may be worked backwards, so as by means of work to raise heat from a colder to a hotter body. This is the principle of the air or ether freezing machines now coming into extensive use. In this application a small quantity of work goes a long way, as the range of temperature through which the heat has to be raised is but small.

If the work required for the freezing machine is obtained from a steam-engine, the final result of the operation is that a fall of heat in the prime mover is made to produce a rise of heat in the freezing machine, and the question arises whether this operation may be effected without the intervention of mechanical work. The problem here proposed is solved in Carré's freezing apparatus, described in most of the text-books on heat. There are two communicating vessels, A and B, which are used alternately as boiler and condenser. In the first part of the operation aqueous ammonia is heated in A, until the gas is driven off and condensed under considerable pressure in B, which is kept cool with water. Here we have a fall of heat, the absorption taking place at the high temperature and the emission at the lower. In the second part of the operation A is kept cool, and the water in it soon recovers its power of absorbing the ammonia gas, which rapidly distils over. The object to be cooled is placed in contact with B, and heat passes from the colder to the hotter body. Finally, the apparatus is restored to its original condition, and therefore satisfies the definition of a heat-engine. M. Carré has invented a continuously working machine on this principle, which is said to be very efficient.

Other freezing arrangements depending on solution or chemical action may be brought under the same principle, if the cycle of operations be made complete.

When heat passes from a hotter to a colder body without producing work, or some equivalent effect such as raising other heat from a colder to a hotter body, energy is said to be dissipated, and an opportunity of doing work has been lost never to return. If on the other hand the fall of heat is fully utilised, there is no dissipation, as the original condition of things might be restored at pleasure; but in practice the full amount of work can never be obtained, in consequence of friction and the other imperfections of our machines.

The prevention of unnecessary dissipation is the guide to economy of fuel in industrial operations. Of this a good example is afforded by the regenerating furnaces of Mr. Siemens, in which the burnt gases are passed through a passage stacked with fire-bricks, and are not allowed to escape until their temperature is reduced to a very moderate point. After a time the products of combustion are passed into another passage, and the unburnt gaseous fuel and air are introduced through that which has previously been heated. The efficiency of the arrangement depends in great degree on the fact that the cold fuel is brought first into contact with the colder parts of the flue, and does not take heat from the hotter parts until it has itself become hot. In this way the fall of heat is never great, and there is comparatively little dissipation.

The principal difficulty in economy of fuel arises from the fact that the whole fall of heat from the temperature of the furnace is seldom available for one purpose. Thus in the iron smelting furnaces heat below the temperature of melting iron is absolutely useless. But when the spent gases are used for raising steam, the same heat is used over again at another part of its fall. There is no reason why this process should not be carried further. All the heat discharged from non-condensing steam-engines, which is more than nine-tenths of the whole, might be used for warming or drying, or other operations in which only low temperature heat is necessary.

The chemical bearings of the theory of dissipation are

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* A lecture given at the Royal Institution on Friday, March 5, 1875, by Lord Rayleigh, M.A., F.R.S., M.R.I.

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very important, but have not hitherto received much attention. A chemical transformation is impossible, if its occurrence would involve the opposite of dissipation (for which there is no convenient word); but it is not true, on the other hand, that a transformation which would involve dissipation must necessarily take place. Otherwise, the existence of explosives like gunpowder would be impossible. It is often stated that the development of heat is the criterion of the possibility of a proposed transformation, though exceptions to this rule are extremely well known. It is sufficient to mention the solution of a salt in water. This operation involves dissipation, or it would not occur, and it is not difficult to see how work might have been obtained in the process. The water may be placed under a piston in a cylinder maintained at a rigorously constant temperature, and the piston slowly raised until all the water is evaporated, and its tension reduced to the point at which the salt would begin to absorb it at the temperature in question. After the salt and vapour are in contact, the piston is made to descend until the solution is effected. In this process work is gained, since the pressure under the piston during the expansion is greater than at the corresponding stage of the contraction. If the salt is dissolved in the ordinary way energy is dissipated, an opportunity of doing work at the expense of low temperature heat has been missed and will not return.

The difficulty in applying thermodynamical principles to chemistry arises from the fact that chemical transformations cannot generally be supposed to take place in a reversible manner, even although unlimited time be allowed. Some progress has, however, recently been made, and the experiments of Debray on the influence of pressure on the evolution of carbonic anhydride from chalk throw considerable light on the matter. By properly accommodating the pressure and temperature, the constituents of chalk may be separated or recompounded without dissipation, or rather dissipation may theoretically be reduced without limit by making the operation slowly enough.

The possibility of chemical action must often depend on the density of the reacting substances. A mixture of oxygen and hydrogen in the proper proportions may be exploded by an electric spark at the atmospheric pressure, and energy will be dissipated. In this operation the spark itself need not be considered, as a given spark is capable of exploding any quantity of gas. Suppose, now, that previously to explosion the gas is expanded at constant temperature, and then after explosion brought back to the former volume. Since in the combination there is a condensation to two-thirds, the pressure required to compress the aqueous vapour is less than that exercised at the same volume by the uncombined gases, and accordingly work is gained on the whole. Hence the explosion in the expanded state involves less dissipation than in the condensed state, and the amount of the difference may be increased without limit by carrying the expansion far enough. It follow that beyond a certain point of rarity the explosion cannot be made, as it could not then involve any dissipation. But although the tendency to combine diminishes as the gas becomes rarer, the heat developed during the combination remains approximately constant.

It must be remembered that the heat of combination is generally developed at a high temperature, and that therefore work may be done during the cooling of the products of combustion. If, therefore, it is a necessity of the case that the act of combustion should take place at a high temperature, the possibility of explosion will cease at an earlier point of rarefaction than would otherwise have been the case.

It may probably be found that many mixtures which show no tendency to explode under ordinary conditions will become explosive when sufficiently condensed.

NOTES

THE *Bonner Zeitung* publishes [a letter of Dr. Seeliger, containing the first detailed reports from the German party of observers sent to the Auckland Islands to observe the Transit of Venus. Dr. Seeliger speaks of the weather in these islands as the most wretched imaginable; enough, he says, to drive an astronomer to despair. "Clear evenings are very rare, and sunshine a phenomenon." On Dec. 9, at 12.45 P.M., "Venus was to appear on the sun's disc; one minute passes after another, and still all is covered. At last the clouds thin a little, and without dark glass we can easily see Venus, that had just entered on the sun's disc. The two first contacts, which, however, were of less value to us, were lost therefore. A quarter of an hour afterwards a little gap shows itself in the clouds, the sun breaks through, and we at once set to work, so as not to lose a single moment. And now comes the wonder! For nearly four hours the sun remains completely free from clouds. In the east and in the west thick clouds; only where the sun stands it is clear. Hardly has Venus passed off the sun's disc, therefore hardly have we completely succeeded with our measurements, when the sky is again overcast all over. To-day the day is dull, as usual. As affairs stand we shall very likely have to stop here two or two-and-a-half months longer, because we have not yet been able to do anything for the other astronomical data, which are indispensable. On the one hand it is hardly possible to do anything in this climate at this time, and then we finished our general preparations only a long time after we thought we should do so."

WE regret to record the death of Carl Ludwig Christian Becker, who has for so long been known to students of physical science in this country in connection with the firm of Elliott Brothers. He was born at Ratzeburg, in the Grand Duchy of Mecklenburg Strelitz, July 16, 1821, and received his general education at the Gymnasium of his birthplace, of which his father was Rector. He studied his profession with Repsold at Hamburg, Kraft at Vienna, and Steinheil at Munich, and came to London in 1849, joining the firm of Elliott Brothers in 1858. Within the last few years he became a member of the Society of Telegraph Engineers and Fellow of the Royal Astronomical and Physical Societies. We believe that there is no one who has pursued physical inquiries in England who will not look upon his loss as that of a personal friend, while his skill in providing new appliances for investigation reminds us how often the most important scientific work is dependent upon the skilled mechanician.

THE Royal Academy of Medicine at Brussels has given its opinion on the so-called "miracle," Louise Lateau, who, it is said, by divine assistance abstains from taking food, and has done so for years together. Moreover, this miraculous creature has some wounds in her hands, side, and feet, which are said to be true representations of those of Christ, and which bleed profusely every Friday. Dr. Virchow, the celebrated German anatomist, has made her the subject of a little pamphlet, "Ueber Wunder." The opinion of the Brussels Academy, which is quite in accordance with that of Dr. Virchow, is as follows:—"Louise Lateau works and requires heat; every Friday she loses a certain quantity of blood by her wounds. When she breathes, she exhales water vapour and carbonic acid; her weight has not decreased since she has been observed; she therefore consumes carbon which is not furnished by her system. Where does she take this carbon from? Physiology simply replies, 'She eats.' The alleged abstinence from all food of Louise Lateau is contradictory to all physiological laws; it is therefore hardly necessary to prove that this abstinence is an invention. Whoever alleges that Louise Lateau is not subject to physiological laws, must prove it; until this is done physiology will denote the miracle to be a deception. Could Louise Lateau be

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